Microscopes.
Age of Trees.
Meteorites.

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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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Vol. XXVIII, No. 10 DECEMBER, 1934 Whole No. 239

DEVELOPMENT OF OUR EARLY KNOWLEDGE CONCERNING MAGNIFICATION*

By William W. Ford

ANY clear transparent object with one convex surface and one flat surface or two convex surfaces acts as a magnifier, and the statement is often made that the use of such materials for magnification goes back many centuries. Thus large convex pieces of rock crystal were found by Layard in the ruins of a palace at Nimrud below the ancient city of Nineveh in Assyria. It is now agreed that such pieces of crystal could not have been used as lenses to enlarge the size of objects because of their uneven surfaces and bands, but that they probably served as ornaments to be worn on the chest. Various references to spectacles can be found in ancient Chinese writings, but such glasses were undoubtedly employed for the protection of the eyes and not as an aid to vision. A knowledge of the principle of magnification may be very old, however. Euclid in the third century B.C. investigated the laws of refraction, and Seneca apparently grasped the idea. In his "Questiones Naturales," written about 63 B.C., he states that "letters, however small and dim, are comparatively larger and distinct when seen through a glass globe filled with water." The appreciation of this principle is also closely associated with the manufacture of spectacles with the distinct purpose of improving the sight. These probably arose among the Venetian glass workers, and their discovery is usually attributed to Salvino d'Amarto degli Amarti of Florence and Allesandro della Spina of Pisa. The evidence for this is not entirely satisfactory.

*This article is reprinted from *Science*, June 29, 1934. Its author is professor of Bacteriology in the Johns Hopkins University.—*Editor.*

Cole[1] says that Francesco Redi (1626-1697), physician, naturalist, poet, mentions probably the first written reference to spectacles in a manuscript, dated 1289, written by a monk who says that he could neither read nor write without the glasses called *occhiali* for the improvement of his vision. Rolleston,[2] however, says that the "Lilium Medicinae" of Bernard de Gordon of Montpellier, published in 1305 or 1306, contains the first notice of spectacles.

How far back in history the use of simple lenses goes is equally doubtful. It has sometimes been claimed that ancient gems could not have been cut and fashioned into jewelry without an aid to the sight, and that engraved and illuminated texts required some magnification for their preparation. Locy[3] states that George Hoefnagel published in 1592 a set of fifty plates of insects engraved on copper. These pictures were drawn by his son Jacob, and some indicate the use of magnifying glasses. These plates of Hoefnagel are, as far as known, the earliest printed figures of magnified objects. The naturalist Mouffet also probably employed simple lenses (Locy[3]). His "Theater of Insects" (*Insectorum sive animalium minimorum theatrum*) was prepared in manuscript as early as 1590, but was not published till 1634. Some of the illustrations in this book show magnification.

All evidence of this character, tending to show rather indirectly that simple lenses must have been used at various early periods in the world's history, is of little importance. The real development of the knowledge of magnification came from the work of the mathematicians and the physicists, beginning with Euclid in the third century B.C. Ptolemy of Alexandria, about A.D. 153, in his mathematical and astronomical investigations probably was the first to study the laws of the refraction of light thoroughly. We owe our knowledge of the optical properties of curved mirrors primarily to the Arabian Alhazen or Al Haitham (Hasan ibn al Hasan ibn al Haitham, Abu Ali, 965-1038). Locy gives 1052 A.D. as the date of his manuscript. Simple lenses were familiar to Roger Bacon (1214-1294), who cleared up many of the laws of reflection and re-

[1]Cole, Ann. Med. Hist., viii: 4, 347-359, 1926.

[2]Rolleston, "Internal Medicine in Clio Medica," p. 35, 1930.

[3]Locy, "Growth of Biology," p. 199, 1925.

fraction of light and suggested their use for bettering the vision. He is indeed sometimes called the "Father of Microscopy." Leonardo da Vinci (1452-1519) also studied the optical properties of lenses and developed the camera obscura, Maurelico the mathematician (1494-1575) in his turn investigated them and Niblo of Poland made a very complete study of the refraction produced by air, water and glass.

Simple microscopes, *i.e.,* simple lenses attached to crude stands, were in all probability first described by Descartes in 1637 in his "Dioptrique." This instrument had a magnifier and a concave mirror with the concavity towards the objects to be examined. In 1671 Athanasius Kircher, a Jesuit priest, made a crude simple microscope by attaching the object studied to a stage with a kind of rest. This instrument gave an enlargement of about 32 diameters, and Kircher was apparently the first individual to note the use of simple lenses for the study of living materials. He may also have had a kind of compound microscope with lenses made of small glass globules.

The greatest development of simple microscopes, and we even say their perfection, came at the hands of Antony (Antoni) van Leeuwenhoek of Delft (1632-1723). He was descended from a good Dutch family of brewers and at the age of 16 went to Amsterdam and became bookkeeper and cashier in a clothing establishment. He returned to Delft after a few years, married at the age of 22 and six years later took a minor office as "Chamberlain of the Sheriff" in the Delft Court. The position was that of a beadle and the pay amounted to £26 a year. This post Leeuwenhoek held for 39 years and the stipend continued to the end of his days.

Early in life Leeuwenhoek became interested in the manufacture of lenses, having observed that by grinding them with diamond dust he could greatly improve their usefulness. He preferred small ones of short focal distance, fastened them to various types of stages and manufactured a large number, owning 419 instruments, including 247 simple microscopes and 172 lenses set between pieces of metal. These lenses were all of glass, except three of quartz or rock crystal. Half of them were mounted in silver, three in gold. At Leeuwenhoek's death he bequeathed 26 simple microscopes, made from lenses ground by himself and set in silver, to the Royal Society of London.

They were examined by Henry Baker and described by him in "The Microscope Made Easy" in 1742. He states that the lenses in these 26 microscopes were all of the double convex variety and not spheres or globules. Soon after Baker's description these instruments were lost sight of and they have never been recovered. An original Leeuwenhoek microscope now exists in the University of Utrecht.

Charles Singer[4] believes that the highest magnification obtained in Leeuwenhoek's microscopes was 160 diameters, and it varied from 40 to 133 diameters. It is interesting to note that the front lens of the modern oil immersion objective is practically the same in structure as Leeuwenhoek's simple lens. No one has ever seen as much as he did with simple microscopes, and soon after his work appeared compound instruments began to be improved and offered greater optical advantages to the scientist. The simple microscope has survived, however, as the hand lens of the physician and the dissecting microscope of the laboratory. It is not without interest that Charles Darwin took one with him on the voyage of the *Beagle* in 1832.

The empirical discovery of the compound microscope is ultimately bound up with the discovery of the telescope, and there are three claimants to the honours. Singer states that these are Zacharias Jansen, Jan Lippershey and James Metius, also known as Jacob Adrianzoon. The date of the discovery of the microscope may be placed between 1591 and 1608. By this time both convex and concave lenses were well known and constantly used in the manufacture of spectacles. Zacharias Jansen (1580-16—?) was the son of a spectacle maker of Middleburg, Holland, and by accident discovered that if he put two lenses in a tube they increased the size of objects. This instrument was perhaps provided with two convex lenses, the lower one having a short focal length to look at near objects. Such an instrument was called a flea-glass or fly-glass, because it was employed to examine small objects like fleas or flies.

The claim of Jan Lippershey tothe honour of the discovery of the telescope rests primarily upon the Acts of the States-General

[4]Singer, "Steps Leading to the Invention of the First Optical Apparatus," in "Studies in the History and Method of Science," Vol. II, p. 385, 1921.

preserved in the Government Archives at the Hague. Here it is stated that on October 2, 1608, the Assembly of the States considered the petition of Jan Lippershey, a spectacle maker, native of Wesel and a resident of Middleburg, who had invented an instrument for seeing at a distance. He was subsequently employed to manufacture three of his instruments from rock crystal. Singer[5] believes that these were provided with convex objectives and concave eyepieces and did not invert the image. In the same month James Metius of Alkomar also petitioned the Assembly of the States for the exclusive right to sell an instrument of his invention to make distant objects appear larger and more distinct. This James Metius was the son of Adrian Metius, burgomaster of Alkomar in 1573. He also accidentally put two lenses together in a tube and found that he could see distant objects. The instruments of Lippershey and Metius were called spy-glasses, and their military importance called attention to their usefulness.

The Jansens began to manufacture both types of instruments, flea-glasses or fly-glasses (microscopes) and spy-glasses (telescopes) in the early part of the seventeenth century. According to the testimony of William Boreel (1591-1668), Dutch ambassador to France, given in a letter to Pierre Borel (1620-1671) the Jansens presented one of their instruments, probably the telescope, to Prince Maurice, the governor and supreme commander of the United Dutch forces. They also gave a microscope to the Austrian Archduke Albert, supreme governor of Holland. Afterwards, in 1619, when Boreel was ambassador to England, Cornelius Drebbel showed him this instrument which the archduke had presented to Drebbel, who was a mathematician. Drebbel himself began to manufacture microscopes in 1621.

The scientific discoverer of the telescope was Galileo (1564-1642), but some doubt still exists as to his relationship to the discovery of the microscope. In 1609 he heard a rumor of the invention by a Dutchman of an instrument by means of which a distant object could be made to appear distinct and near. Immediately he made use of his knowledge of the laws of refraction to construct a similar instrument along exact lines. He fastened two lenses at

[5]Singer, *ibid.*, p. 408.

the ends of a leaden tube, one plano-concave, one plano-convex. Looking through the concave eyepiece he observed that objects seen were three times nearer and nine times larger than when observed with the naked eye. He rapidly improved the construction of the instruments, getting one through which objects were a thousand times greater and thirty-fold nearer than if observed by the unaided vision. Examples of Galileo's telescopes are still in existence, preserved in the Galileo Museum in Florence. It should be noted that the principle of the telescope is to have an objective which focuses at infinity (or far objects). As to Galileo's discovery of the microscope, *i.e.*, an optical insturment for seeing near objects magnified, our knowledge of his contributions is somewhat casual. John Wodderborn, a Scotch student who attended Galileo's lectures at Padua, stated in 1610 (see Fahie[6]) that he had often heard Galileo describe the employment of an instrument for the examination of insects, and similar evidence is given by the Frenchman, Jean Tarde (Fahie[7]). There is also some reason to believe that Galileo presented a microscope to the King of Poland in 1612. As stated above, Cornelius Drebbel began to manufacture microscopes in 1621 and Jacob Kuffler, a relative of Drebbel, brought such an instrument to Rome as a present from Nicholas Fabri de Peirese of Paris (1580-1637) to one of the cardinals. Two years later two others arrived. One of them was constructed of two lenses, and nobody in Rome could understand its use. At that time Galileo came to Rome, and on being shown the apparatus stated that he himself had previously made such instruments "which magnified things as much as 50,000 times, so that one sees a fly as large as a hen." He soon made some instruments showing objects erect and not inverted. These were called fly-glasses, *occhiale*, later *occhialino*. Unfortunately, we have no satisfactory knowledge of the construction of the fly-glasses. Two relics of them are in the Tribuna di Galileo, Florence, but the lenses are missing and there is some doubt as to the genuineness of the tubes.

The term "microscope" was introduced by Giovanni Faber in a

[6]Fahie, "The Scientific Works of Galileo (1564-1642)" in "Studies in the History and Method of Science," Vol. II, p. 206, 1921.

[7]Fahie, *ibid.*, p. 229.

letter of April 26, 1625, to the Academy of the Lincei and was applied to the instrument constructed by Galileo to look at small things and called by him *occhiale*. The lyceum also gave the name "telescope" to a similar instrument of Galileo's, but designed to look at objects at a distance.

Galileo's explanation of the path of light in the bilenticular system is usually regarded as unsatisfactory but was improved by Kepler (1571-1630) in his "Dioptrice" (Cologne, 1611). Kepler suggested the construction of both telescopes and microscopes with two convex lenses, the theoretical forerunners of our modern instruments. Actually the manufacture of microscopes has followed in general the lines laid down by the Jansens. Instruments began to be made in considerable quantity in Holland by the middle of the seventeenth century. Fontana in 1646 improved the Jansen microscope by substituting a positive eyepiece for the negative, *i.e.*, one with the real image of the objective below all the lenses of the ocular, rather than with the real image between these lenses, and thus getting a magnification much greater than that obtained by the Jansens. This type of microscope evidently remained in use for some years, for Otto Fredrik Müller (1730-1784) used an instrument designed by the Jansens and improved by Fontana. It is said to have given a magnification of over 300 diameters. This increase of magnification over that given by Leeuwenhoek's best instruments, about 160 diameters, marked the doom of the simple microscope, certainly for the study of bacteria, and since then the chief efforts of physicists have been devoted to improving compound microscopes. Other types have been invented from time to time, among which may be mentioned those of Hooke (1665), Bonnani (1697) and Divini, who exhibited a kind of compound microscope before the Royal Society in 1668. To Hooke the credit of adding the field piece to the ocular is sometimes given. Huygens in 1660 was familiar with the field piece, however, for he manufactured negative oculars with the real image below the field piece and above the other lenses in the ocular. He used a plano-convex field piece and a plano-convex eyepiece, both convexities facing downward.

The chief difficulty in microscopes lies in the chromatic aberration. As lenses of shorter focal distance (less than 1 inch) and

more nearly spherical are employed, the obliquity of the rays so greatly increases the aberration that false colours are introduced, and definition becomes defective. The limitation of the size of the aperture to keep down the chromatic aberration shuts out the light and makes the field too dark for successful vision. A similar difficulty arises with the telescope. The first achromatic telescope was probably made by Chester Moor Hall of Essex, England, in 1733. Hall combined lenses of different refracting indices and made a telescope which gave a vision of objects free from color. In 1759 Dollond, on the basis of Swedish investigations on the dispersion of refracted light, made a telescope with lenses of different kinds of glass with respect to the divergence of colour. His object glasses gave almost complete correction of the chromatic aberration; later the spherical aberration was corrected by the same means.

Not until the early part of the nineteenth century, however, was this principle applied to the construction of microscopes. In 1812 Amici of Modena made the first attempt at an achromatization of the objectives along the lines marked out by Dollond. The chromatic aberration of the objectives was corrected by a combination of plano-convex lenses of flint glass with biconvex lenses of crown glass. He also employed a highly curved plano-convex front lens with a numerical aperture of 105. The spherical aberration was done away with by a combination of convex and concave surfaces of different curvatures. In 1830 Lister (the father of Lord Lister) worked out another principle for the correction of aberration by having the image point of one lens coincide with the object point of another and a few microscopes have been made with this design. Selligues and Chevalier of Paris superimposed three or four combinations, each of double convex lenses of crown glass cemented to plano-convex lenses of flint. By 1837 excellent microscopes were available, giving a high magnification and a clear definition. Amici discovered the principle of water immersion lenses and Andrew Ross in 1839 invented a collar adjustment for them. The water lens was greatly improved by Hartnack in 1855. The first microscopist to employ oil instead of water was apparently Wenham, who demonstrated the use of cedar oil before the Royal Microscopical Society in June, 1870.

A little later Stephenson in 1878 also employed the principle of oil immersion for lenses and at his suggestion Abbe manufactured the first effective immersion lens in which cedar oil was utilized. About this time a number of improvements in the construction of microscopes were made, chiefly by Abbe, who profited greatly by Helmholz's investigations on the undulatory nature of light. In 1886 he made an apochromatic objective in which the secondary spectrum was not noticeable and the spherical aberration corrected for three colours. This was used with a compensating ocular of Jena glass. Abbe also introduced the substage condenser which goes by his name, the final improvement in the construction of microscopes which has given us our modern high-powered instruments of such wonderful utility and beauty.

THE MAY, 1934, MEETING OF THE ROYAL SOCIETY OF CANADA

By A. Vibert Douglas*

The annual May meeting of the Royal Society of Canada was held in the Chateau Frontenac, Quebec, from May 21 to 24. Fellows, delegates and visitors from Pacific to Atlantic gathered there for three days of meetings and informal discussions.

The number of strictly astronomical papers presented in Section III (sub-section Mathematics and Astronomy) was not large: of the 18 papers, 13 were mathematical and only five were definitely astronomical. In addition to these, however, several papers presented before the general Physics section may be mentioned.

The Dominion Astrophysical Observatory contributed three papers. One, by J. S. Plaskett, F.R.S.C., and J. A. Pearce, F.R.S.C., was entitled, "The dimensions of the galaxy determined from the motions of class B stars". Their investigations lead to a reduction in the size of our galaxy which brings it into line with the generally accepted dimensions of the Andromeda nebula—a typical spiral galaxy. Heretofore our galaxy has been regarded as so much larger than the average spiral galaxy that an eminent American astronomer likened it to a continent and the spirals to islands. Sir Arthur Eddington and others have doubted the validity of this distinction and so it is of particular interest and importance to have fresh evidence brought forward.

W. E. Harper, F.R.S.C., presented the spectroscopic elements of i 44 Boötis. The fainter component of this visual binary is found to be a spectroscopic eclipsing binary with 6-hour period and mass ratio approximately two to one.

A paper on "The Intensities of Interstellar Lines" was contributed by C. S. Beals, F.R.S.C.—a study of the relative intensities of members of the sodium doubtlet and an attempt to interpre tthe

*Professor Douglas attended the meeting as the representative of the Royal Astronomical Society of Canada.—*Editor.*

results in terms of thermal Doppler effects, radiation damping and the galactic rotation Doppler effects.

From the Dominion Observatory came four papers. R. Meldrum Stewart discussed the "Law of decrement for oscillatory motion under atmospheric friction". This paper gave a solution for conditions intermediate between the exponential decrement when resistance varies as velocity and the harmonic progression when resistance varies as the velocity squared.

C. C. Smith reported upon "The 1933 International Longitude Measurements made at Ottawa and Vancouver". As one link in a chain of worldwide effort to determine any relative movements of the land masses of the earth, an intensive study of clock corrections and wireless time comparisons were made from September 15 to December 15, and this paper dealt with these observations, methods and results, with special reference to the limits of accuracy.

A. H. Miller and W. G. Hughson contributed a paper on "Gravity and Isostasy in Canada". Gravity stations have been occupied from Halifax to Victoria across southern Canada, and also up the Mackenzie River basin. Reductions by four standard methods show that there is almost complete isostatic equilibrium throughout these regions which comprise about one-third of the total area of Canada; but two areas of anomaly are reported, a negative area in the east and a positive area in the prairies. Mr. Miller also reported upon his magnetometric and gravitational survey of Grand Rapids iron ore deposit, Ontario. All this forms a part of an extensive programme of gravitational and magnetic survey work undertaken some years ago by the Dominion Observatory.

From McGill University came a paper on "The Stark Effect in Stellar Spectra", presented by the writer on behalf of J. S. Foster F.R.S.C., and herself. The profiles of four helium lines in the spectra of some B-type stars have been analyzed to reveal the presence of the weaker adjacent lines which appear only if the helium atoms are absorbing light in the presence of an electric field. Fields up to 60 kilovolts per cm. are found to be fairly widespread. After allowing for the known Stark effect lines, a residual helium band remains on the violet side of the four lines λλ4922, 4471, 4388, 4026 and its presence suggests an emission of helium from these stellar atmospheres.

Among other papers which may be mentioned are the following: "The Height of the Aurora Borealis", from 500 photographic determinations at Saskatoon, giving an average height of 105 km., by T. Alty and F. J. Wilson; "Progress of polar air from high to low latitudes across Canada", by Andrew Thomson, who explained the severe 1933-34 winter in eastern Canada as due to the cold air moving directly S.-E. or E. instead of S. as it had done for at least three winters previously; "Stark Effect in Hydrogen Isotopes", by J. S. Foster, F.R.S.C., and A. H. Snell. The heavy isotope of hydrogen recently discovered has been spectroscopically examined in electric fields. (This isotope appears to be present in terrestrial sources in the proportion of approximately one to 5,000 ordinary hydrogen atoms, yet there is no trace of it in solar or stellar spectra. Here is a problem of some considerable interest to the astrophysicist.)

RADIO TALKS OVER CFCT, VICTORIA, B.C.

By W. E. HARPER

No. 70.—ARE THE CONTINENTS SEPARATING?

(November 21, 1933)

SEVENTY-ONE per cent. of the earth's surface is water, and the remaining twenty-nine per cent. is divided into several large land areas known as continents. The question we are seeking to answer is whether these continents remain relatively fixed with respect to each other, or whether there are changes taking place in the distances separating them. We are not concerned at the moment with the movements of small areas which may be gradually rising or falling, resulting in what was formerly land becoming sea or vice versa. What we are thinking of is the movement of whole continents towards each other or apart from each other.

It has been long known to geologists that the visible part of the earth's crust consists chiefly of the lighter and more acid rocks, and beneath this it has been commonly supposed that there lies a layer of the denser and more basic rocks. The interior core must be denser still. The outer crust, having an average thickness of possibly 60 miles, floats as it were on the denser intermediate mass. Naturally below the ocean bed it is thinner than on land but it has been generally supposed that it covers the whole globe.

Somewhat at variance with this general conception has been the view held by Wegener that the continents are not definitely joined below the ocean bed but are floating separately on the denser mass and that their relative positions have altered greatly in quite recent geological times. Indeed the idea is that originally all the land was united in one mass. This mass broke up and the continents separated from each other until they occupy the positions in which we now find them.

The evidence for a former union of the continental masses is strongest in the southern hemisphere. We can mentally picture how easy it would be to piece together South America and Africa, the eastern extremity of Brazil fitting into the indentation on the west

coast of Africa. But more striking than the configurations of the coast lines is the fact that the rocks and fossils of the areas are so closely akin as to lead geologists to the belief of a former land connection. Numerous other arguments of a geological, biological or climatic nature were adduced by Wegener to substantiate his hypothesis, according to which the American and European continents were separating at the rate of about three feet per year.

The only method by which the reality of such movements can be tested is an astronomical one. Through the observation of the exact instant a star crosses our north-and-south line in the heavens two observers, though situated a thousand or more miles apart, can determine such distance separating them with an accuracy which a layman would hardly credit. Before the advent of the wireless telegraph, when recourse was had to the telegraph and cable for comparisons for time, it was considered that the error was not greater than 1/40 of a second, which corresponds to a distance of about forty feet. It is not generally known by Canadians that the first girdle of the earth, through such longitude determinations, was made from our national observatory at Ottawa a few months after the Pacific cable was completed in 1902. From Bamfield on the west coast of Vancouver Island to Doubtless Bay, New Zealand, the stretch is 8,273 nautical, or about 9,700 statute, miles. The closing error when determinations made one way around the world were compared with those made the opposite way was only 84 feet, giving one an idea of the precision of such astronomical determinations of position.

With the advent of wireless has come increased accuracy in recording the time of an event such as the passage of a star over a cross-wire in the field of the telescope. Corresponding improvements have been effected in the observation of the star itself so that much greater accuracy is possible now than attainable thirty years ago.

At all the large observatories the wireless signals that are sent out at stated times each day from such stations as Paris, Nauen and Annapolis are compared with the times as determined from the stars themselves. A systematic study shows seasonal differences of the order of about 1/20 second, many times the probable error of deter-

mination. What the cause is remains obscure though there are several suggestions to account for it. A slight correlation seems to have been established with the moon's place in the sky. We know that the moon produces a tide on the solid crust of the earth akin to that on the ocean and it may be of sufficient magnitude to vitiate the time observations on the stars. All such systematic errors must, of course, be removed from the observations before we could ever hope to decide for or against the idea of the continents separating or approaching a few feet per year.

An international program was carried out in the autumn of 1926 to obtain data on such continental drift and our Canadian observers occupied Ottawa and Vancouver as two points on the world-wide girdle. That program is now being repeated, though on a much larger scale than in 1926, for there are three world girdling circuits. The first comprises Greenwich, Tokio, Vancouver and Ottawa; the second Algiers, Zika-Wei and San Diego; and the third, Cape Town, Adelaide, Wellington and Buenos Ayres. Besides these, nearly one hundred fixed observatories have agreed to take some share in the work. The work is nearly over now as October and November (1933) were the two months assigned. As formerly, Canada is occupying the stations at Ottawa and Vancouver.

The results are sent to Paris and studied by a Commission appointed by the International Astronomical Union which met at Cambridge, Mass., in 1932. When the studies have been completed we ought to have some conclusive evidence for or against the continental drift theory.

No. 71.—TREE RINGS.

(December 19, 1933)

Those of you who have been listening in to these monthly chats on astronomy will wonder what on earth trees and their rings have to do with astronomy. There is a very close relationship, however, because all growth upon the earth is dependent in the final analysis upon the sun and it is only reasonable to suppose that we can infer something about the sun's condition in the past by studying the growth of trees, as indicated by their rings.

I assume, of course, that you are all familiar with the rings

which a cross section of a tree displays. In the spring the trees put on a rapid growth of soft white tissue overlying the entire surface. This continues until lack of moisture or cold weather diminishes the growth and stimulates the tree to prepare for winter by putting on a darker, harder ring. A year's growth, then, includes both the light and dark portions of the ring.

If successive years were exactly alike, the rings would all be of the same size, with some accidental variations. Such accidents might be a forest fire, which for many years would impede its usual rate of growth. Insect pests might be more plentiful in some years than others, again creating an accidental factor. But the main causes contributory to tree growth are, of course, rain and sunshine. In the case of trees in the centre of a great forest, where the moisture is retained from year to year and does not vary greatly, one would expect to find a more or less uniform growth. But in sparsely wooded lands where there is no reserve precipitation from year to year the growth of trees can reasonably be expected to show a direct correlation with sunshine and rainfall.

Now our sun is known to undergo changes of a cyclical character. At times dark spots are seen on its surface, the so-called sun spots. These are huge eruptions or volcanoes which belch forth immense volumes of gases through openings so large that they could contain a dozen earths. For some years, as at present, these spots are few; gradually the number increases until there is a maximum disturbed condition of its surface; then the number gradually diminishes to a minimum. This cycle takes 11½ years to complete, or as recent discoveries would seem to indicate, double that period, *i.e.* 23 years, since there is greater similarity between alternate than between consecutive cycles.

Astronomer A. E. Douglass, formerly of the Lowell observatory, now of Steward observatory in Arizona, in studying the nature of sun spots sought corroborative evidence of their cyclical character. It seemed to him that the pine trees of northern Arizona with no dense undergrowth and exposed to the characteristic droughts of the country, would be most likely to show variations in growth depending upon the main controlling factor, rainfall. He examined cross sections of nearly one thousand trees, measured the thicknesses of several hundred thousand rings are found a correlation be-

tween the growth and the rainfall of between 80 and 85 per cent. Others had shown that for Arizona, and California too, there is a direct relation between rainfall and the sun spot cycle, so that the variations in growth of these trees were directly related to the sun spot cycle.

But he was not satisfied with anything short of 100 per cent. agreement. When the older trees were examined which carried the test back to the year 1650 and beyond, the variations for a number of years (1660 to 1720) seemed to vanish. This led him to doubt the reality of the correlation; but eventually in 1919 he published the facts as he found them. Three years later the English astronomer, Maunder, found from his exhaustive study of the records that there was a prolonged dearth of spots between 1645 and 1715, thereby corroborating the actual results of Douglass in a remarkable manner.

Sun spot observations, of course, do not date back much earlier than 1645, as they were seen for the first time when Galileo pointed his newly invented telescope at the sun in 1610. But the records of older and older trees all agree in carrying this period of the sun's relative quiescence back to about the year 1400. Beyond that the variation in the yearly growth of the rings follows in general the 23 year cycle as it has since about the year 1700.

Now the Arizona pines, like our Douglas fir, are not a particularly long-lived tree. The big fir trees at Cathedral Grove near Cameron Lake on this island are approximately 300 to 400 years old, and to carry the historical record back farther one must secure timbers from an earlier epoch which have in some way been preserved for our deciphering. There must be a sufficient overlap, say 40 or 50 years, so that there will be no doubt of the identification. The ring pattern must match in all particulars. By means of old timbers taken from cave dwellings of early races of Indians in the southwestern States Douglass has been able to establish a complete chronology dating back to eight centuries before the landing of Columbus. The story of this piecing together of the records yielded by timbers from old ruins is as thrilling as the best detective story one can find. At all stages it was checked by similar variations found in the rings of the slow-growing sequoias of California, which attain the ripe old age of 3000 or 4000 years.

Thus Douglass, starting out as an astronomer, developed into a meteorologist and ended up as an archaeologist by dating the ruins of buildings left by these Indian races who roamed the Arizona plains centuries before the coming of the white man. It was my privilege to see the moving picture of the passage of the years from 700 A.D. to the present as delineated by a composite photograph of these tree rings and to note the "lean" years and "fat" years for tree growth which were accompanied in many instances by corroborative historical evidence. It was intensely interesting.

No. 72.—MORE TALES FROM TREE RINGS.

(January 16, 1934)

In my last radio address I brought to your notice in a preliminary way the work of Astronomer A. E. Douglass of Arizona in deciphering the messages furnished by the yearly growth of trees in his State. By measurement of such yearly growth of the trees, as indicated by the characteristic rings which a cross-section of a tree displays, he was able to establish that there is a close correspondence between the growth and the number of spots or disturbed areas on the sun. These come and go in cycles of 11½ years and the curve representing tree growth follows closely the waxing and waning of the spots throughout the cycle.

The trees seem to jot down each year a memo of their eventful lives. Such memo shows whether or not they have had sufficient moisture to nourish them and how the sunlight has shone upon them. Moreover, they record if they have had to fight off diseases due to insect pests or have suffered injury from forest fires or other causes. In the the rings of the "talkative" pines of Northern Arizona the "lean" years and the "fat" years, as regards tree growth, were faithfully recorded. In this section of the country precipitation is the controlling factor and these rings are nature's best rain gauges, serving as the magic key to open to us the records of past years.

While the early specimens examined were of trees only 100 years old it was possible through overlapping these with earlier timbers, preserved in old ruins, to establish a complete chronology dating back to 700 A.D. Thus Douglass developed the history of drought and

plenty in this plateau country for 1200 years and could point with certainty to certain years such as 1632, 1379, 1067 and 840 as being years of excessive drought in this region.

Interesting sidelights on this investigation were the studies in archaeology which it made use of or brought about. In his search for old timbers to complete the span of the early years he was wisely guided to the most likely sites by the type of pottery whose fragments were found in the different ruins. A sequence of development was noted which does not concern us here further than to note that it enabled Douglass to search for old timbers in the most likely places. It was interesting to note too that the best timbers, fir and pine, were among the earliest to disappear after a tribe had located in any spot, showing that the story of the depletion of natural resources is not by any means confined to the present age. In those days when such occurred the tribes simply moved to another district and began anew. In our day such is not possible and we ought to have some regard to conservation for the future. As a further clue to old-age timbers those were selected whose ends showed that they were haggled in two by the stone axes in use before the Spaniards introduced the sharp steel axe about the year 1540.

When the complete chronology had been established in the tree ring system back to 700 A.D. Douglass was able to tell from the timbers in each of the ruins just when these Indian villages were established and to trace the movements of these tribes from one place to another.

As explained in my last talk, the 11½-years cycle broke down in the years between 1660 and 1720 and until Maunder had shown that there were very few sun spots in that same period much doubt was cast upon the correlation in other years. The exact correspondence between tree growth and the numbers of the sun spots cannot be carried back farther than about 1645, for while there are references to naked-eye observations of the spots by the Chinese in 188 A.D. it was not until after the invention of the telescope in 1610 that any worth-while record of their number could be made.

But if there is a one-to-one correspondence in the rings, then these will tell us how the sun has been behaving in the past. Now one theory has it that these sunspots are a relatively recent acquisition of the sun—recent from the standpoint of astronomical time. The

evidence from the ring system built up by Douglass from the Arizona pines, supplemented by that of the 4000-year-old sequoias of California, is that, superimposed on the usual 11½ year cycle there are other secondary cycles of different periods. From 1300 B.C. to well after 1000 B.C. the 11-year cycle was well developed; then it slowly decreased. From 300 B.C. onward it was increasing and was very conspicuous during the first two centuries of our era. Then it decreased to 650 A.D., persisted then to 900 A.D. and lapsed until about 1250. Since then, with the short lapse in the latter part of the 17th century, already referred to, it has been continuous.

In this connection a very interesting supplementary research has been carried out by one of my former colleagues, Dr. Ralph E. DeLury, at Ottawa, on a section of a spruce tree recovered from a glacier in northern British Columbia and supposed to have been buried at least 60,000, and possibly 300,000 years, ago. A section of this pre-glacial spruce may be seen in our Provincial Museum. DeLury measured the annual rings of this 170-year-old tree and found a close correspondence between yearly growth and the 11-year sun spot cycle, maximum growth taking place as usual at the time of maximum sun spottedness.

As a hobby a few years ago I studied sections of some of the Douglas firs cut down on Observatory Hill. The oldest tree of which I received a cross-section was 235 years old and this showed the double cycle of 11½ years very nicely. My procedure was to sandpaper the cross-section to bring out the rings clearly, make a photographic plate and from it measure the rings with the measuring microscope.

A number of things was impressed upon me by such simple studies, one of which was that you cannot always judge the age of a tree by its size. Two trees had been cut down within ten feet of each other, one considerably larger than the other, which before measurement I judged to be 20 or 30 years older than the smaller one. As it turned out they were of the same age and, seeking the cause, I found that the smaller tree had been a twin, the other member of which had been cut down a few years earlier. Evidently there had not been sufficient nourishment to supply both their needs and stunted growth was the result.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

Japanese Meteorites

An interesting communication has been received from Mr. Y. Iba who has established an amateur observatory in Kobe, Japan, and who has shown considerable interest in searching old Japanese records for accounts of ancient meteor showers. The following is quoted from his letter:—

In October, 1932, I went to a small town, Miki, situated N.W. of Kobe and within reach of 45-minute drive, with view to examine siderites that struck the roof of a farmer's house (Mr. J. Kuriyama) in 1930.

According to the couple who witnessed the incident, at about noon on May 27th a rumbling sound aroused their attention, but, trusting that it was the roaring of a motor truck, they were about to take tiffin when all of a sudden a sound "bang" above their head startled them. They rushed out to ascertain what had happened and witnessed a stream of vapour arising from the ditch in the background, and digged out main portion of meteorite. One small fragment, as seen in the plate, was found on the ground under the roof and was too hot to pick it up outright.

The roaring sound in the sky which lasted for some time was so striking that mechanics, busily engaged in the making of farm implements amidst a boisterous clamour of running motors, had to stop swinging their hammers to listen to it.

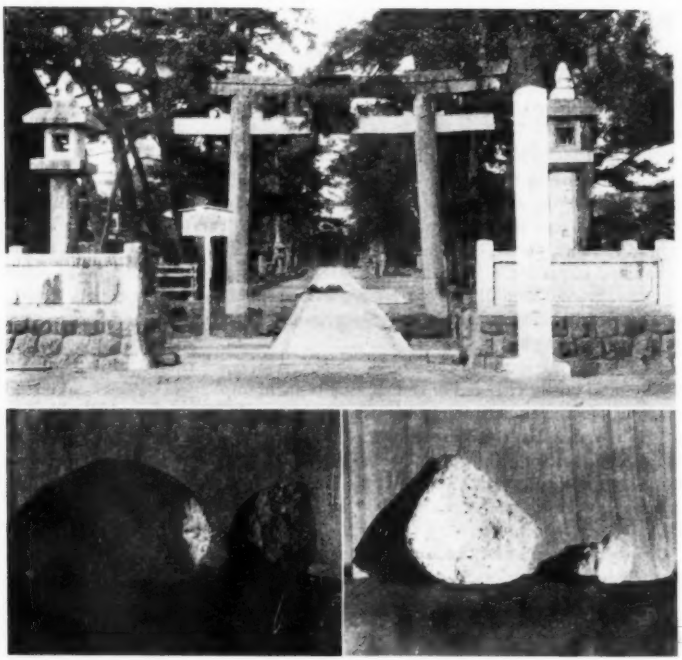
The exterior surface of meteorite, which has a gravel-like appearance, looks as if it was smoked, showing blackish-brown colour. The cracked part presents light sky-blue tint with yellowish granular particles intermixed. Main portion weighs 0.038 kg. and fragment 0.008 kg., and their dimensions are 4 by 3 and 2 by 1 cm., respectively.

For the sound and the mass of meteorite, the damage was very slight, only one tile having been cracked.

The writer has communicated with Mr. Iba concerning a more detailed study of this stone.

While speaking of metrorites in Japan it is of interest to note that there is a supposed meteorite in the grounds of the Yoshida Shrine in the town of Toyohashi, where the writer lived as a boy. The object lies almost on the central line of the cement walk leading to the main building of the shrine and this walk has been laid out of line for a matter of twelve or fifteen feet in order to avoid the meteorite. The latter is partially buried in the ground and, as far as can be remembered, measures about three by one-and-a-half feet at the ground level. The surface is smooth, somewhat pitted, and the general colouration is that of weathered copper. The sub-

stance is hard. The writer tried one night to remove a small piece for analysis but practically no impression could be made with an ordinary cold chisel. It was found difficult to arrange with the shrine authorities for the removal of a fragment as they were distinctly averse to the thought of tampering with the stone. Below



Above.—The Yoshida Shrine, Toyohashi, Japan, showing meteorite in centre of walk. *Below.*—Two views of the pair of stones which fell at Miki, Japan, May 27, 1930.

is a quotation translated directly from an old Japanese book in possession of the priest at the shrine:

THE METEORITE IN THE GROUNDS OF YOSHIDA SHRINE

The "Darkfall" stone is lying ten steps from the "Torii" towards the main building. It is indeed a wonderful stone which everyone is anxious to see. In ancient times the sky suddenly became dark and rain and hail began to fall violently. Then this stone, called "Darkfall", came down from the sky. Many people refuse to believe this story but in ancient times stones often fell from the sky. In the age of Emperor Konin, the seventh year (816 A.D.), ninth month,

from the twentieth day every evening stones fell from the sky. In the age of Keicho, fifteenth year (1610 A.D.), fourth month, ninth day, in Hijika of the mountains of Mikawa country five stones measuring each four or five feet across fell with a great noise and trembling like thunder. And in the age of Kanki, second year (?), tenth month, sixth day, stones fell from the sky. These stones were about the size of oranges.

Photographic Observations of the 1934 Perseids

Photographic observations of the Perseids were made at several stations in conjunction with the visual observations reported last month. The writer was assisted by Mr. J. M. Millman in the programme at the David Dunlap Observatory where three spectrographs and two direct cameras were used. The lenses of the spectrographs had aperture ratios of 4.5, those of the direct cameras aperture ratios of 1.25. In previous photographic programmes considerable trouble had been encountered with either dew or frost, both of which seem particularly troublesome in the neighbourhood of Toronto. Heaters for the spectrographs were constructed in the laboratory and these have proved entirely satisfactory in preventing both frost and dew from being deposited on the lenses and prisms. Chromel C wire No. 25 was wound into one-quarter-inch coils and these coils were then wrapped about the dew caps of the spectrographs, the dew caps having first been insulated with several layers of brown paper and shellac. About 60 feet of wire was used on each spectrograph and the heaters were put in series and plugged in to the regular 110-volt circuit. One to three carbon lamps in parallel in the same circuit guard against blowing a fuse and prevent the heaters from becoming too warm. When in the laboratory the heating of the coils is just perceptible to the hand.

Eastman I C Special Spectroscopic plates were used on all the spectrographs in an effort to secure a photograph of a meteor spectrum in the red. These plates are sensitive to all wavelengths from the ultra violet to the *Hα* line but have a particularly high sensitivity in the neighbourhood of λ6300. They have proved to be very much faster than any other red sensitive plates tested by the writer and were used during the Leonid and Geminid observations in 1933. Exposures were continued throughout each of the three nights of observation (Aug. 10-Aug. 13) though clouds were very troublesome on the last two dates. Four Perseid spectra were photographed, all faint. Two of these photographs were of the same object taken with different cameras. The visual magnitudes

of the three meteors were estimated as −3, −4, and −4. All three show the *H* and *K* lines of calcium and two show faint detail in the red. A trail of a −2 magnitude meteor was photographed on Aug. 11-12 with the direct cameras. A more detailed record of the exposures will be found in the table.

PHOTOGRAPHIC EXPOSURES ON THE PERSEIDS

Station and Date	Spectrophotography			Direct Photography		
	Plates Exposed	Hours Exposed	Spectra Photog.	Plates Exposed	Hours Exposed	Trails Photog.
David Dunlap Obs.						
Aug. 10-11.....	21	18.2	..	7	3.1	..
Aug. 11-12.....	22	15.7	2	23	9.0	1
Aug. 12-13.....	17	16.8	2	9	5.2	..
Georgian Bay, Ont.						
Aug. 10-11.....				3	2.8	1
Aug. 12-13.....				2	2.3	..
Norway Bay, Que.						
Aug. 11-12.....				6	6.0	4
Totals.....		50.7	4		28.4	6

Mr. E. W. Bullock used a direct camera with aperture ratio 1.25 on Georgian Bay, Ont., and photographed a Perseid on Aug. 10-11. This meteor was, unfortunately, not visually observed. Mr. F. W. Matley used two direct cameras at Norway Bay, Que. These had aperture ratios 4.5 and 6.3 and in six exposures on Aug. 11-12 he secured four photographs of two meteors, thus demonstrating what can be done by the interested photographer with standard camera equipment. One of the meteors photographed by Mr. Matley was of magnitude −3, the other was not visually recorded.

The writer notes in *Popular Astronomy* for October that Prof. Whitney of Pomona College, California, photographed a meteor spectrum during the Perseid observations. The spectrograph in this case was mounted in a novel manner. Four spectrographs were continually rotated on an axis at an angular speed corresponding to the expected velocity of the meteors. Since the cameras thus followed up the meteors the effective light intensity on the plate was increased. Strangely enough, though the rotation was adjusted to conform with the motion of the Perseids, the meteor photographed was a non-Perseid. P. M. M.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Death of A. W. Megget at Winnipeg

From Mrs. S. C. Norris, secretary of the Winnipeg Centre, comes the information that Mr. Megget is dead. She describes him as "our much loved past president" and "a wonderful worker in the interests of astronomy". From a newspaper clipping enclosed the following sketch has been compiled.

Archibald W. Megget was born at Halstead, Essex, England, on January 6, 1865, the son of Dr. and Mrs. A. Megget. His family later moved to Scarborough, from which place they came to Canada in 1883. He received his early education at the Norfolk County school and became a member of the school cricket team in 1879. Thus he commenced a career as a devotee of the favourite English game, which included membership of teams at Kemnay, Brandon and Winnipeg, and of the Western Canada eleven which visited the United States some forty years ago.

Before coming to Canada, Mr. Meggett was a student in the Medical school of Edinburgh university. For eleven years he farmed at Kemnay, Manitoba.

In 1894 he entered the employment of the Manitoba and North Western Railway, and when this road was absorbed by the C.P.R. in 1900, he moved to Winnipeg and became well-known as a professional violinist and leader of Barraclough's orchestra. He was a competent teacher of the violin. In addition to his musical activities and his continued interest in cricket, he taught boxing and fencing at St. John's college. His proficiency in both of these arts won him several trophies in his college days at Edinburgh.

He was a keen and capable horticulturist and his home near the river bank at St. James was a beauty spot by day. With the going down of the sun he turned his attention to the "flowers of the sky", and no one in Winnipeg was more familiar with the constellations and their movements. As an amateur astronomer he delighted to allow visitors see the wonders of the heavens through his telescope, and when the unexpected stranger followed the beaten pathway to his door and begged a peep at the sky, Mr. Megget's personal inconvenience would be forgotten in his enthusiastic desire to share with others a study which gave him so much pleasure.

For many years he was a member of the Winnipeg Centre of the Royal Astronomical Society of Canada, and was elected president for the year 1933. In that organization as well as in cricket and musical circles and among the staff of the Manitoba Telephone System, with whom he had been associated since 1918, his loss will be keenly felt. He passed away on August 18 and thus terminated a life full of wholesome activity. He was a citizen loved and respected by all who knew him.

There survive his widow and four married daughters: Mrs. G. Evans, Birtle, Man.; Mrs. D. P. Allen, Winnipeg; Mrs. Leonard Miller, London, Ont.; and Mrs. Norman Hughes, Winnipeg. There remain also a sister and two brothers, namely, Mrs. Frank Waring and Ernest E. Megget, both in Ceylon, and Cecil Megget in Escondido, Cal.

Mr. D. R. P. Coats, the president of the Winnipeg Centre, said:

"I first met Mr. A. W. Megget on the evening of March 13, 1923. It was the occasion of the official opening of CKY, and the initial programme was performed by members of the staff of the Manitoba Telephone System. Mr. Megget contributed a violin solo, and we discovered in conversation our mutual interest in astronomy. I count the subsequent years among the richest of my life for having given me the enjoyment of his friendship.

Carlyle said of a great poet that he was a true gentleman because he loved everything—'the mouse and the daisy, and all the things, great and small, that God had made'. So could it be said of Mr. Megget. In him were combined proficiency in manly sports and a gentle nature which endeared him to all who knew him.

As a member of our Winnipeg Branch of the Royal Astronomical Society of Canada, he seemed to be the hub around whom we all revolved. Some of us might miss the odd meeting, but Mr. Megget was always there and his accurate knowledge of the heavers was always there for us to draw upon whenever a speaker was needed."

Site for the 200-inch Telescope

The Associated Press states that, after a search lasting for ten years, a site has been chosen for the 200-inch telescope. It was thought that the best atmospheric conditions would be found at a considerable elevation and not too near the ocean on the west or the desert on the east; and, further, it was desirable that it should be easily accessible from Pasadena. The place chosen is on Palomar mountain, a peak about eighty miles northeast of San Diego. On September 22 representatives of the California Institute of Technology, which is in charge of the great project, met William Beech on the Beech ranch on the mountain to make final arrangements to acquire the site for the new observatory.

Stars Visible in the Pleiades

The number of stars visible with the unaided eye in the Pleiades cluster is always of interest to the astronomer. To the average observer only six can be seen, but by allowing the light to enter the eye obliquely, some observers can detect a larger number. Miss Airy, the daughter of the English Astronomer Royal, counted twelve. Rev. W. R. Dawes, who was credited with very acute

eyesight, saw thirteen. Kepler states that his scholar, Michel Möstlin, could distinguish fourteen, while Carl von Littrow is said to have seen sixteen. A colleague of the present writer, Professor T. R. Rosebrugh, states that some years ago he used to exercise his eyes on the Pleiades and that, although he considered his eyesight somewhat faulty, he could detect thirteen stars.

An Observatory for Auckland, N.Z., Wanted

Professor P. W. Burbidge of Auckland University College a few months ago paid a visit to America, including Toronto in his itinerary; and on his return lectured, on August 8, before the Auckland Institute and Museum, on the Mount Wilson Observatory. Undoubtedly he found enough to talk about. During the lecture he stressed the fact that Auckland is without adequate facilities to carry on astronomical research and he looked forward to the day when some interested citizens would assist in providing astronomical equipment reasonably commensurate with the size of the city. The present writer remembers well his visit to Auckland in 1922 and wishes Professor Burbidge abundant success in his campaign for suitable observatory facilities.

The Amateur's Telescope

On several occasions in these Notes, attention has been directed to the admirable book, "Amateur Telescope Making", prepared by Albert G. Ingalls, one of the editors of *Scientific American*. In a recent publication of the New Zealand Astronomical Society appears a review by Allan Bryce of a little book entitled "The Amateur's Telescope", by Rev. W. F. A. Ellison, director of the Armagh Observatory, and published by R. Carswell & Sons, Belfast. It contains 107 pages and the price is 7*s.* 6*d.* The first edition appeared in 1920 and was a reprint of articles which Mr. Ellison had contributed to the *English Mechanic* in 1918. Mr. Ingalls in his book pays a high tribute to Mr. Ellison and indicates those parts which are borrowed from Ellison's publication. The third edition of Ingalls' book runs to 500 pages and contains a large amount of matter of great interest to amateur astronomers—and professionals, too. A picture of Mr. Bryce beside his home-made 8-inch reflector is to be found in *Scientific American* for February, 1933.

C. A. C.

MEETINGS OF THE SOCIETY

AT WINNIPEG

March 14, 1934.—The meeting was held in Theatre "F", University Building at 8.15 p.m., and was presided over by Mr. D. R. P. Coats.

Mr. C. Wilcox was elected to membership.

Mr. A. W. Megget gave his usual ten-minute talk on "Celestial Events of the Month", noting the finest visible bodies, as Spica Virginis, Regulus the kingly star, Pollux and the planet Jupiter, whose moons were first observed by Galileo.

The address of the evening was given by Mr. W. H. Darracott, F.R.A.S., who spoke on the "Constitution of the Stars". Mr. Darracott referred to the tremendous advance made in the study of the stellar universe in the past few years. The estimated number of stars has grown from 3 to 4 billions in 1922 to 30 to 40 billions, and the number of the so-called "island universes" has increased accordingly. The limits of space are now considered as trillions of light years away—according to Eddington *seven* trillions.

What a star is and how it came was dealt with. A star is a self-luminous gaseous sphere, probably liquid in the centre. The distance is measured by parallax from opposite sides of the earth's orbit around the sun, which means a distance of 183 millions of miles from which to measure the angle. The hotter the star, from the warm red, the warmer white, to the hottest blue, it is the more luminous. The giant star Capella is said to be 130 times more luminous than our sun, with a diameter of 12 million miles. Red Antares, 390 million miles in diameter, is the largest that has been measured. The mass of the stars is much the same, the most massive, 80 times that of the sun, the least one-fifth that of the sun. There must be equilibrium between the forces acting on the body both exterior and interior, radiation prsesure outwards and gravitational pull inwards.

Different classes of stars were considered from the giant and supre-giant bodies to the white dwarfs like the dark companion of Sirius on which a cubic inch would weigh a ton; its density 60,000 times that of water. Red giants having 300 times the diameter of the sun have been measured and dwarfs about a quarter his diameter. Such a body as the latter comes nearest the conception of absolute solidity.

There seem to be great changes going on in the universe and the problem is ever present—What is happening to the stars we see? As a star shrinks its brightness increases for a time, then fades as it ages. The effect of high temperature is to vaporize but that of high pressure is to compact. By the use of the spectroscope—the colour indicator—the constituents of a star and its age are discovered through the analysis of light rays. Its temperature density and all other properties are also obtainable.

The diameter of Antares was measured some years ago, at Mt. Wilson by

the interferometer method. This consists of a 20-foot beam fastened to the end of the telescope, and by the use of mirrors, placed at intervals, the star light is reflected, when the "critical distance" is focused by the sliding mirrors (at which the appearance of dark bands crossing the star disappear), its diameter can be calculated.

Mars could revolve in its present orbit 53 million miles inside the circumference of Antares.

The diminutive white dwarfs when shrunken to their limit or the *degenerate gas state* may suddenly flare into first magnitude brightness by exploding, and if in a state of rotation, may part in two, forming two dwarfs; or one may remain a dense dwarf as before and the other gathering its electrons together again may mount from dwarf to full size, like Sirius and its companion; or both may become a double, or two giant stars.

Every star may possibly go through the nova state, at least once. After the outburst, the mother star may shrink again rapidly, but regain its former brightness. Its spectrum shows streams of gas similar to solar prominences thrown off by the greatly increased radiation pressure. Though much progress has been made in the last ten years, the evolution of the universe is still a question. To be solved or not to be, only the future will reveal.

March 28, 1934.—A regular meeting was held in the usual place. President D. R. P. Coats was in the chair.

Mr. E. C. Bridges was elected to membership in the Society.

The President reminded the members that the University books on astronomy were available to them for their use at any time. In the absence of Mr. A. W. Megget, Mr. Coats read clippings of aerial and spectroscopic observations which had been made in the Old Country, of great interest to the scientific world.

Prof. G. H. Herriot gave the address of the evening on "Locating One's Position from the Stars". Referring to astronomy, the speaker said that the task of the surveyor would be an insurmountable one but for his knowledge and use made of the fixed stars, and his faith in the Almighty Ruler of the Universe. Tribute was paid to the many astronomers who have given so much time and thought to the mechanism of the heavens, from which great practical help has been obtained. A transit instrument was used to demonstrate the manner of making observations, both vertical and horizontal, for the finding of necessary data, as time, latitude, longitude, and azimuth or vertical circle. Different systems of geodetic survey work were explained and illustrated by charts and diagrams, and also the use made of the sidereal clock for making the necessary computations. Observations are made with Polaris (which is 1° 3′ from the pole), and an adjacent star, the motion of the polar stars having the least apparent motion. Great land masses, as mountains, influence the action of transits, which may register as much as 1000′ in error, and corrections must be carefully made with the instrument used.

Different types of transits were shown, their mechanism explained, and the mode of correcting to guard against possible errors.

April 11, 1934.—The annual members' night was held in Theatre "F", University Building, at 8.15 p.m., Mr. D. R. P. Coats presiding. Miss Mae Wilson, 1479 Elgin Ave., was nominated for membership.

There were four speakers for the evening, three being past presidents.

Mrs. E. L. Taylor spoke on "Things Known in Immensity", meaning, she explained, things generally accepted as facts in the astronomic world of thinkers. The speaker stressed the wonders and achievements of the human mind in having reached out to the distant bodies of planets, fixed stars, the Milky Way (of which our own Solar System forms an infinitesimal part) and on to other Milky Ways—so called island universes—and has found their composition, including elements unknown on the earth; their size; and has practically weighed them in the balance, though perhaps millions of light-years away. In the past three years tremendous strides have been made in this study. Seemingly dark or empty spaces have been found well populated with stars or nebulae, of star clusters. The possibility and probability of life in these other worlds than ours was touched on—life as known to us, or unknown. Considering the advance made in the recent past, what may be expected in the future? Future astronomers will tell the tale.

Mr. C. E. Bastin gave the next address, on "The Solar System", our home in the universe. The use of a telescope—even a small one— was urged by the speaker, since our own solar system presents many interesting objects for observation. Sun spots, he said can be studied to advantage, with a darkened glass, and much information learned. Mercury is interesting, but too near the sun to be easily seen. The best time for observation is shortly before sunrise. The phases of Venus, like those of the moon can be distinctly followed by observation. And perhaps the most interesting of all is our own satellite the moon. Its lofty mountains, much higher accordingly than those of the earth, and deep craters are a continual source of interest and pleasure to observers. Mars with its theoretic "canals", snow-clad polar caps with seeming seasonal appearance and disappearance, atmosphere with clouds, and vegetation (?) seems to be a probable home for life little different from our own. Jupiter, the giant, larger than all the rest of the planets in the solar system, with its retinue of 9 moons,—four of which can be seen with even a small glass—is rather difficult for observation because of the belts or bands—supposed to be layers of clouds—over the visible surface. Saturn with its rings and nine moons is always a very beautiful object. So, our own system provides much of interest and gratification to any observer and perhaps most of all to the amateur.

Mr. A. W. Megget spoke on "Celestial Events of the Month". The skies the speaker said, presented the greatest of all "Movies", with an abundance of romance and mystery awaiting all who care to make their acquaintance, which is an easy matter. While winter stars and constellations are the most brilliant, there are always some of peculiar interest and beauty. Leo with Regulus, one of the Royal Stars, and others of various magnitudes, one of them an orange and green binary; and Virgo with Spica of the first magnitude—really two component stars, a large and small—near which Jupiter can be observed at present, are well worth the time spent in observations. The sun is now passing near Regulus.

Mr. G. P. Morse, of the Public Works Dept., gave the final address of the evening on "Astronomy and Aviation". It was shown that astronomy has a definite practical value to man in travel whether by sea or air. Observations

are taken at intervals, with two fixed stars, as Arcturus with Polaris; or some other fixed star with Polaris, according to which the ship is guided. Navigation by night is found to be more certain than by day. Mr. Morse described the partial air-navigation of the Atlantic by Hawker and Grieve in 1919; he estimated from Grieve's sunset sights and the recorded mileage that the change of course at sunset was due to his finding himself too far south; and again at sunrise the readings would show that he had been carried by the increasing wind during the night some 125 miles south of his course laid for Ireland. Then the speaker took the audience on an imaginary trip at night from Vancouver toward New Orleans and described navigation by intersections from the two chosen stars. He also showed one of the latest navigation graphical charts for position. The Lindberghs use these charts in their air-navigation. So the study of astronomy may be a delightful past-time and also is a very practical science for the use of man.

Observation Night

May 21, 1934.—This evening the members held an Observation Night. Four telescopes were set up in the grounds of the University of Manitoba and full advantage was taken of the clear sky and excellent visibility which favoured the observers.

Mr. A. W. Meggett showed some of the wonders of the heavens with his three-inch refractor; the Society's refractor, also of three inches aperture, was in the capable hands of Mr. L. T. S. Norris-Elye, while the President, Mr. D. R.P. Coats, managed two six-inch reflectors, both equatorially mounted and entirely of his own construction. One of these is equipped with a clock drive made from phonograph motors. The tube is of iron, bound with polished brass and finished in cloud-grey enamel. The second reflector is of the tubeless type, the mirror, prism, etc., being attached to an oak rod and the whole mounted equatorially on a base built of pipe fittings. The numerous members who attended had ample opportunities for comparing the relative merits and disadvantages of both reflectors and refractors. Jupiter was on his best behaviour and ran the moon a close second. Among the objects most interesting to the celestial tourists were also Vega, Albireo, the double double in Lyra, the Twins, Arcturus and others. Mr. Norris-Elye "re-discovered" Neptune for many members who saw this planet for the first time. Each telescope was surrounded by a group who listened to and discussed the various phenomena observed.

May 29, 1934.—On this evening members of Winnipeg Centre had the pleasure of again meeting their esteemed Honorary President when he was their guest at a dinner in Moore's Coffee Inn. President D. R. P. Coats occupied the chair and Dr. N. J. Maclean, Dr. Plaskett's host, introduced the visitor and speaker for the evening. While he was in the east, Queen's University conferred the honorary degree of doctor of laws on Dr. Plaskett, another tribute to his scholarship and attainments. He attended the annual meeting of the Royal Society of Canada and then in Cleveland advised regarding the construction of a large telescope for a Texas observatory. Dr. Plaskett spoke particularly on the galaxy, of which our sun is a very insignificant member, revolving with all

the other suns of the Milky Way once in 220 million years—quite a leisurely rate, according to the speaker. For centuries, astronomers concentrated on the solar system and its motions, Copernicus, Galileo, Kepler, Newton and others. From the middle of the 19th century, the galaxy was the centre of attraction to Kapteyn, Shapley of Harvard, Trumper, Stebbins and others. And still the galaxy holds unknown quantities to be solved or verified—perhaps. Sir John Herschel studied the galaxy and made computations by the trigonometric method, finding its diameter about 100,000 light years, but this method was found to be far from satisfactory. Since that time—comparatively recently—by the analytical method, the diameter was reduced to 7000 or 8000 light years. Some astronomers—Shapley and others—had increased the diameter of the galaxy to 300 thousand light years. Experiments at the Victoria observatory under Drs. Plaskett and Pearce have again reduced it to 150,000 or 200,000 light years.

Our solar system has been estimated to be about 35,000 light years from the centre of the galaxy, and about two-thirds the distance from the centre to the circumference.

Mr. W. H. Darracott, F.R.A.S., London, proposed the vote of thanks to Dr. Plaskett, and Mr. L. T. S. Norris-Elye seconded it; which brought to a close a very enjoyable evening. J. C. HOWEY, *Recorder*.

AT VANCOUVER

Summer Meetings.—In addition to the regular meetings of the Centre, four special observation meetings were scheduled. The following members very kindly offered their homes and astronomical equipment: Mr. J. Teasdale, Mr. H. C. B. Forsyth, Mr. C. E. MacKenzie, and Mr. H. P. Newton. Owing to unfavourable weather, the meeting at the home of Mr. H. C. B. Forsyth was cancelled.

The following reports have been submitted by Mr. Teasdale and Mr. Newton respectively.

The first outdoor meeting of the Centre for 1934 was held July 28th at the home of Mr. J. Teasdale. About 30 people assembled, most of whom were non-members. No members having brought portable telescopes, the only one available was the six-inch reflector. The evening was not promising, visibility being poor and seeing only moderate. No planets were favourably placed for observation at the time, but several double stars were observed. As the moon rose to an observing attitude a brief glimpse was obtained of her before gathering clouds shut out the view and soon the whole sky was obscured.

The meeting was honoured by the presence during the latter part of it by Mr. J. R. Collins of Toronto, for many years prominent in the activities of the Society. In conversation with members, Mr. Collins tendered the greetings of the eastern Centre and showed much interest in the work of the western Centres.

The second meeting was on Saturday, September 1st, at the home of Mr. H. P. Newton.

Night clear, definition poor.

Instruments: Mr. McGrathe's 3-inch refractor. Mr. H. P. Newton's 5½-inch equatorial refractor, by Sir Howard Grubb, Dublin.

Objects observed: *Stars:*—Alpha Lyrae, Alpha Boötis, Alpha Herculis, demonstrating the difference in colour of the spectral types.

Double Stars:—Polaris, Alpha Herculis, eta Cassiopeiae, pi Aquilae, epsilon Lyrae, zeta Ursae Majoris, etc.

Clusters and Nebulae:—M 13, and 92, the bright globular star clusters in Hercules. M57, the ring Nebula in Lyra. M31. The great white Nebula in Andromeda and the adjacent nebula, M32, and H.V. 18.

Planet:—Saturn, but here, as with the double stars, the tremulous atmosphere did not give the telescopes a chance to show their resolving powers. However Cassini's Division in the right system was easily visible in the 5½-inch refractor, and most of the members present could see five of the satellites,—Tethys, Dione, Rhea, Titan, Iapetus, which had been charted previously, for 9 p.m., for identification, as there were numerous faint stars in the field.

In conclusion a McLean's star spectroscope was attached to the 5½-inch and some spectra were shown. Alpha Aquilae and Alpha Lyrae. Type A., Polaris, F8, Alpha Boötis, K., Alpha Herculis, M7, and gamma cassiopeiae, Bp, the hydrogen lines bright.

About a dozen members were present.

October 9, 1934.—The twenty-fifth regular meeting of the Centre was held on Tuesday, at 8.15 p.m., Dr. William Ure presiding.

R. G. Bowden, 1536 Kitchener St., Vancouver, was elected a member.

The President reminded members that the election of officers would be made in December and outlined the method of nominating candidates.

Mr. Paul Sykes then gave a very able and instructive summary of the positions of Constellations and of planets in the October skies. Later, after the meeting had adjourned, Mr. Sykes took charge of an observation group on the University campus.

The chief speaker of the evening was Professor A. E. Hennings, member of the Department of Physics of the University of British Columbia. He illustrated his subject, "Clouds and Weather Phenomena", by a number of interesting lantern slides.

In the earlier part of his lecture, the speaker considered the earth as a body surrounded by an envelope of gases, consisting mainly of nitrogen and oxygen, in a continuous turmoil with water vapour. "On the average" stated Dr. Hennings, "16,000,000 tons of water evaporate every second", and he compared the process to a huge perpetual motion engine, with the sun as the chief source of power. He showed that the problem of weather forecasting is a difficult one, particularly because of the large scales involved on the earth and because of the complicated conditions of rotation and revolution. The speaker then described "Low" and "High" points of pressure, and illustrated his remarks by showing weather maps indicating the paths of storms.

The members were extremely interested in the lecturer's explanation of the cause of rain and fogs, and of the various kinds of clouds. Dr. Hennings referred particularly to the cumulus, the cirro-cumulus, and the alto-cumulus.

In conclusion he discussed the formation of the rainbow, the halo, and the corona.

The interest of the audience was shown by the very large number of questions asked at the close of the lecture.

WALTER H. GAGE, *Secretary.*

AT VICTORIA

The Summer Course in Astronomy has been a phenomenal success this year. The reason for this success, it is surmised, is due not only to the popularity of the lectures but also particularly to the fact that those attending the series were afforded an opportunity of studying the stars through telescopes provided for the purpose by certain members of the Centre. A great deal of credit is also due to our President, H. Boyd Brydon, who instigated the movement three years ago and who for the first session placed his magnificent telescope and also his home at the disposal of those attending the series. Since that time the popularity in the series has grown with the result that it is a foregone conclusion that the Summer Courses operated by this Centre in the future will be one of its greatest accomplishments and assets. This year the series opened on July 9 with an address by the president on "Astronomy as a Recreation". This was followed by nine further weekly meetings when the following lectures were delivered:

Science and the Future, by Dr. C. S. Beals, F.R.C.S.
How Big are the Stars? How Far Away are They?, by W. E. Harper, M.A.
How Old are the Stars?, by Dr. J. A. Pearce.
Some Peculiar Stars, by Dr. Helen S. Hogg.
The Sun, by Gordon Shaw.
The Moon, by P. H. Hughes, Mus. Bac.
The Earth, by Lieut. Commdr. R. H. Tingley, R.C.N.
The Other Planets, by G. Brown-Cave.
How Did the Solar System Come About?, by Charles Hartley, M.A.

There was an average attendance of 59 persons at the meetings the largest number at any one meeting being 81 when Mr. Hughes, our immediate Past President, spoke so entertainingly on "The Moon". Most of the lectures were illustrated with lantern slides and all, without exception, were admirably presented. In order to accommodate the audience it was found necessary to secure the laboratory premises of the Victoria College which were very generously placed at our disposal by the Board of School Trustees for the City of Victoria. Approximately 200 star charts were distributed amongst those attending the series and a programme of the lectures. It is indeed gratifying to be able to report that the Summer Course was operated at a profit and that as a direct result of same seventeen new members were secured to the Centre. The officers and Council take this opportunity of expressing their very best thanks to the lecturers and those who kindly loaned telescopes as well as to all others who so kindly co-operated in making the session the signal success it undoubtedly was.

September 21, 1934.—The autumn session opened when Dr. R. O. Redman, Assistant Director, Solar Physics Observatory, Cambridge, England, addressed the Centre on "The Atmosphere of a Star."

In his introductory remarks Dr. Redman stated that the greater part of our observational knowledge of stars comes from a study of the sun and that, therefore, from the astronomer's view-point, our sun is considered as quite a normal and representative star. With the aid of slides and spectrographs of the sun's disc the lecturer indicated some of the characteristics of stars. One of the first slides thrown upon the screen depicted the sun's disc with a marked diminution in surface brightness from centre to edge. This phenomenon, the lecturer stated, was known as "darkening of the limb". There was also evidence, he pointed out, for this darkening in eclipsing binary stars. Measurement of this darkening to the limb, both in white light and in different coloured lights, provided a great check on various theories put forward concerning the structure of the sun's atmosphere. In particular, stated the lecturer, it ruled out a number of theoretically possible structures. With the aid of a series of slides dealing specifically with the spectra of the sun and of all normal stars, the lecturer showed how, through the medium of the spectroscope, definite information had been secured of the presence in the sun of about one-half of the ninety-two known elements which constitute our own earth. This justified the assumption that the chemical constitution of the outer layers of the sun and the stars was closely akin to that of our own planet. After dealing briefly with the various theories which had been adduced on the subject Dr. Redman reminded his audience that even the very best theories so far propounded left a number of important phenomena still unexplained and unaccounted for. In dealing with the work at present being carried out in this direction Dr. Redman took occasion to pay tribute to the activities of Dr. H. H. Plaskett at Oxford, England. There was a large attendance, as was to be expected, and at the conclusion of the address Dr. J. S. Plaskett, F.R.S., and Dr. Helen S. Hogg moved the vote of thanks of the Centre to Dr. Redman for the excellent manner in which he had dealt with what was admittedly a most difficult subject to be treated in a popular manner.

November 2, 1934.—On this date the members of the Victoria Centre were entertained in a novel manner. For the first time in the history of the centre the auditorium was transformed into a workshop, and instead of sitting and listening to a set lecture they were given a practical demonstration of the various processes involved in the constructing of a telescope of the reflecting type. The principal speaker of the evening was Mr. W. R. Hobday, who has charge of the telescope-making section of the centre and who has awakened an enthusiastic interest which is truly contagious. The easy manner in which he manipulated his "tools" and demonstrated the art of mirror grinding proved conclusively that he was "quite at home" in the work, whilst the excellent manner in which he described, in detail, the various processes involved showed very clearly that he was likewise well informed on his subject.

By way of introduction Mr. Hobday briefly discussed the differences between the reflecting and refracting types of telescope. He showed very clearly the difficulties which confronted the amateur in the construction of a refracting type of instrument and gave the reasons why the reflecting type of telescope

was the most simple and best adapted for construction by the amateur. The major part of the address, of course, was concerned with the grinding of the mirror. After explaining fully how this should be accomplished, he proceeded to give an actual demonstration. Taking a six-inch mirror which had been already partially ground, using a coarse abrasive and another piece of glass of the same size as the grinding tool, he carried out the three essential motions whereby a high degree of accuracy could be easily attained by a very rudimentary method. These three motions may be defined as follows: (1) a to-and-fro or up-and-down movement of the upper piece of glass; (2) a circular twisting of the same, and (3) a circular movement completely around the mirror glass. All three movements were carried out simultaneously and in order that the last movement could be accomplished with ease it was suggested that the glass mirror be affixed to a round table or disc which enabled the operator to move around the same whilst the other two motions were in operation. It was interesting to hear Mr. Hobday's description how these three motions, carried out simultaneously, had the effect of forming a spherical depression in the mirror glass which graduated infinitesimally to the centre of the same. This is effected by reason of the fact that the centres of both pieces of glass are constantly in contact with each other whilst the edges were not so during the to-and-fro or up-and-down movement above-mentioned, but were, during that period, overlapping each other at each movement of the hand either up or down. It was explained that three various grades of carborundum were used as abrasives. The first, or coarse grade, whilst accomplishing the rough work in a fairly short time, nevertheless had the effect of creating more or less large holes in the surface of the mirror glass. These were somewhat reduced in size by the application of the second or finer grade of carborundum and were practically eliminated when the last and finest grade of that material was applied. The polishing of the mirror, after the grinding had been completed, was carried out in the circular manner already described but with the application of jeweller's rouge in place of carborundum.

Whilst he was actually demonstrating the grinding of the mirror, Mr. Hobday stated that the whole operation, from start to finish, occupied approximately twenty-two hours, which time could be expended in such manner as best suited the convenience of the operator. It was pointed out that in order to give the mirror a focal length of eight times its diameter (f/8), which, in practice, was found to be the most convenient for the amateur, the depression in the centre of the mirror glass amounted to approximately one sixty-fourth of an inch. Small as this may at first appear, Mr. Hobday stated that as a matter of fact it was possible, by the simple method he was demonstrating, to grind accurately a mirror glass to a depth of 100,000th part of an inch.

To Mr. R. F. Hopkins was accorded the opportunity of giving in more detail the reason why the focal length of f/8—a ratio of 8 to 1—was the most favoured for amateurs and why the six-inch mirror was the most popular to make. This focal length, he explained, was the distance at which an object, reflected by the mirror, would appear as a pin-point of light. The focal length of a six-inch mirror was forty-eight inches and it had been found, by experience and in practice, that this is the most satisfactory distance at which to pick up an object in

the eyepiece. All other distances, it was pointed out, whether greater or smaller, had numerous difficulties which it was hard for the amateur to overcome.

The question of mounting the instrument, when completed, was briefly dealt with by the President, Mr. H. Boyd Brydon, who, with the aid of the four telescopes on view which had been constructed by members of the centre, briefly explained the mechanism and principle involved in the mounting. He also, incidentally, made the interesting announcement that he and Mr. James Duff, M.A., and some other directly interested members of the telescope-making section had devised a system of mounting which, by the combination of a gravity system of rotation and an oil-controlled weight, would take the place of a clock-working arrangement and could be constructed for about $15.

At the conclusion of the meeting most of those present took the opportunity of making a personal inspection of the material used and of actually going through the movements of grinding the mirror which had been used in the demonstration by Mr. Hobday.

October 12, 1934.—On this occasion the members of the Victoria Centre were afforded an opportunity of listening to one of the most interesting and thought-provoking lectures imaginable. The lecturer was Dr. J. S. Plaskett, F.R.S., who spoke on "The Structure and Dimensions of the Galaxy".

This is a subject which has engaged the attention of astronomers for the past 150 years or more and it was most interesting to observe the concise and explicit manner in which the lecturer dealt with the historical side of his subject. Starting with Thomas Wright of Durham, England (1750), Dr. Plaskett reviewed the various theories which had been propounded by the astronomers of the eighteenth century, such as W. Herschel and Lambert, and incidentally referred to the fact that it was on Wright's theory that Kant, in part, founded his philosophical doctrine. According to the earliest computations our galaxy was considered the greatest in the universe but the lecturer pointed out that, towards the end of the eighteenth century, this theory had been greatly modified by reducing its diameter to 6,000 light years. Seeliger, some years later, made a computation of between 20,000 and 30,000 light years, but it was Schwarzschild and Kapteyn who were the first to endeavour to ascertain the dimensions of the galaxy by a definite count of the visible stars. As the result of their labours they advanced the size of the galaxy to a diameter of 55,000 light years with a thickness of 11,000 light years. And there the matter rested for many years. New interest was awakened in the subject in 1929 when Hubble, who had been making photographs of the nebula in Andromeda, at Mount Wilson Observatory, determined its distance as being about 800,000 light years from the sun and having a diameter of approximately 40,000 light-years. This occasioned the putting forward of new hypotheses including that of Shapley, who advanced the idea that our galaxy was not a single nebula, but a cluster of smaller nebulae. A similar hypothesis was advanced by Lundmark, whilst Trumpler, in 1930, stated that, in his opinion the galaxy was much smaller than had previously been supposed and he reduced its size to about 35,000 light-years. Dr. Plaskett made it quite clear that Trumpler's theories were not generally accepted by astronomers but that, nevertheless, his work was of real importance in that it particularly emphasized the fact that

there was some absorbing material present in the galaxy which had the effect, from our observational viewpoint, of dimming the light of the more distant stars. Passing reference was made by the lecturer to the fact that he and Dr. J. A. Pearce, working at the local observatory, had been able to demonstrate that our galaxy was in rotation and that Eddington had made use of this in his publications. On the other hand, such rotation was not included in the hypotheses put forward by Shapley, Lundmark and Trumpler respectively. By easy steps Dr. Plaskett then briefly outlined the views which had been expressed on the matter up to the significant computation made by Stebbins in 1933, which is now generally accepted as being scientifically sound. This gives the galaxy a diameter of 100,000 light-years and a thickness of 10,000 light-years. It can now be safely postulated, said the lecturer, that our own galactic system is in orderly rotation round Saggitarius, taking about two hundred million years for one rotation, and that it is a great spiral nebula similar to the nebula in Andromeda. In his closing remarks, Dr. Plaskett said: "When we have by two entirely different methods obtained practically the same dimensions for the galaxy, we have a lot more confidence in the finalty of the results". He was careful, however, to point out that science might in the course of time have to change its views on the subject for good and sufficient reasons. The lecture was illustrated by numerous slides.

HORACE E. MOORE, *Secretary.*

AT TORONTO

October 16, 1934.—The meeting was held at 8.00 p.m., in the McLennan Laboratory, University of Toronto. In the absence of the chairman, Mr. R. A. Gray, the chair was occupied by A. R. Hassard, K.C., vice-chairman.

Mr. Whitehouse reported observation of a bright meteor on August 14.

Mr. Hassard announced that a "question box" would be initiated as a feature of coming meetings, and that members who had queries of an astronomical nature which they desired answered might place them in the box, and the replies would be presented at the next or a following meeting.

The usual custom of not presenting a formal paper at the first autumn meeting prevailed, and several members reported summer observations and experiences. Mr. S. C. Brown gave an interesting description, illustrated by lantern slides, of a number of nebulae and clusters visible with small telescopes. He mentioned that too few observations are being made and reported by members, and thought that an amateur telescope makers' section, which had been proposed by a number of members, might help to stimulate useful observation.

Mr. J. R. Collins followed with an account of his experiences of a trip during the summer when he visited a number of branches and members of the Society in western Canada.

Mr. F. L. Troyer spoke briefly of the fascination of astronomical observation, and in this connection read two paragraphs from recent literature, one from Dr. Robert H. Baker's new book, "When the Stars Come Out". In connection with observation groups, he expressed the view that active sections with well-organized planning could make many useful observations.

Mr. A. R. Hassard, K.C., then spoke of the subject of water levels in the

Great Lakes, and followed this by a description of a mariner's telescope which he had recently purchased in a Kingston second-hand store.

October 30, 1934.—The meeting was held at the usual time and place. A. R. Hassard, K.C., occupied the chair.

Twenty-one candidates were duly elected to membership in the Society, the first nine being attached to the Toronto Centre, the others being members-at-large, viz.:

Mr. Bruce Annand, 65 Summerhill Avenue, Toronto.
Miss Mildred Brookstone, 82 Baldwin Street, Toronto.
Mr. D. Allister Carmichael, 226 Wychwood Avenue, Toronto.
Miss Mary A. Clendening, 162 Mavety Street, Toronto.
Mr. William O. Erb, Kapuskasing, Ontario.
Mr. Edward J. Langan, 91 St. George St., Toronto (also Stratford, Ont.)
Mr. James McCormick, 78 Erskine Avenue, Toronto.
Miss F. Shirley Patterson, 60 Grosvenor St., Toronto (also Newmarket, Ont.)
Miss Evelyn M. Rutledge, 322 Marks St. S., Fort William, Ont.

Mr. W. H. Almandinger, 158 Murray St., Fort Erie, Ont.
Mr. Alphée Demers, St. Giles, Que.
Mr. Albert Prince, Ste. Thérèse, Co. Terrebonne, Que.
Miss Antoinette J. Turcotte, Manitoba Sanitorium, Ninette, Man.
Rev. J. Coulter, Whissonsett Rectory, East Dereham, Norfolk, England.
Dr. J. E. Craik, 807 Spruce St., Boulder, Colorado.
Rev. A. Emerson Johnson, Monterey, Virginia.
Mr. Alfred Johnson, R.D. 2, Box 43, West Newton, Penn.
Mr. A. T. Lamm, 1010 Union Pacific Bldg., Omaha, Neb.
Rev. A. J. Reine, Catholic Rectory, Elkhart Lake, Wis.
Mr. Edward Trevvett, 70 Genesee St., Utica, N.Y.
Mr. Theodore D. Woolsey, "Green Pastures", Kent, Conn.

Predictions of astronomical phenomena for the following two weeks were outlined by F. L. Troyer. Recent observations were reported by Mr. Hassard and others. J. R. Collins replied to a query presented at the previous meeting: "What is the nature of light"?

Dr. P. M. Millman, of the department of astronomy, University of Toronto, then presented his paper, "Modern Meteoric Research; the Ideal Field for the Amateur". Contrasting meteor observation of a century ago with that of to-day, Dr. Millman stated that until about one hundred years ago meteors were considered as unimportant as the casual lightning flash, and the fact that stones might fall from the sky was ridiculed by almost all persons. The great Leonid meteor shower of 1833 (which was followed by another in 1866) was probably the greatest factor in influencing meteor observation. The discovery that some cometary orbits coincide with the orbits of meteor swarms, together with an accumulation of reports of great unheralded fireballs, was further instrumental in stimulating observation. To-day, more and more profesional astronomers, as well as an ever-increasing group of amateurs, are engaging in the important field of meteor research.

After many years of hesitation, science did eventually demonstrate the fact that stones do fall from the heavens. Careful study of "these little bits of the debris of space", the only tangible evidence which we are able to examine in the laboratory, has given us much information about the heavenly bodies, for these meteorites do not themselves form in space, but must be parts of some larger objects. A study of the velocity of a meteor tells us whether it originated in outside space, or whether it is merely part of our solar system. The results indicate that nearly seventy per cent. of the meteors which we see are from outside the limits of the solar system.

Most meteor trains occur at altitudes of from 90 to 150 km. These are above or at the ionized Kennelly-Heaviside layer. These trains give us information about the upper atmosphere from heights much greater than we can hope to reach by means of the stratosphere balloon.

Until 1931 only nine meteor spectra had been obtained. At the present time we have over thirty, many contributed by amateurs. From a study of these spectra it appears that usually only the iron-nickel meteors penetrate below the ionized layer; the stony meteors, exhibiting calcium lines in the spectra, do not generally seem to come so low.

Dr. Millman emphasized the fact that meteoric observation is the ideal field for amateurs, requiring no expensive equipment or technical training. The amateur can do work just as useful as that of the professional in both visual and photographic observation, and the necessary accuracy and skill in reporting details is easily acquired. Meteors are only local phenomena, a single meteor because of its closeness to the earth being seen over only a small area, and the really spectacular meteors, the great fireballs, always come unheralded.

Dr. Millman closed his address with a demonstration of the meteor shower projector, a novel apparatus which provided a display of meteors of varying magnitudes and velocities against a background of stars.

FREDERIC L. TROYER, *Acting Recorder.*

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